Scientific Manpower*

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Summary—**The most conservative figures on the shortage of engineers suggests that this shortage is now around 95,000 and will reach 156,000 by 1955. A less conservative view of the figures available suggests that this situation might be much worse. The number of new engineers now being produced each year may be actually less than the number lost to engineering activities through death, military service, and transfer to nonengineering duties. We might be 300,000 engineers short by 1955. Since it takes four years to train an engineer, all we can do during the next four years is to make better use of the engineering manpower which will be available. But high-school students are being discouraged from entering the fields of science and engineering by misleading statements of prominent people that science and engineering are the cause of the world's troubles. Engineers and scientists can do much to remove this misapprehension by pointing out that scientists and engineers also work for human welfare and that science and engineering are helping to solve the world's troubles rather than causing them. This must be done and additional scholarship funds be made available before the downward trend in engineering and science enrollments is reversed.**

THERE IS no engineer in the country who has not read dozens of articles and speeches full of statistics on the engineering manpower problem. I apologize in advance for inflicting another one on you.

However, only a few of these articles and speeches go behind the statistics they present and attack the question of what these figures *mean*. I believe there is a deep meaning hidden behind them—one fraught with grave consequences for the future of this nation and the free world. It may be already too late to avoid some of them. But it is vitally important that we recognize them, that we identify the basic causes of the difficulty and try to tackle the stupendous task of remedying these causes.

First we must look at the figures themselves in order to appreciate the dimensions of the problem. And right at this point we run into a jungle of confusion. You can pick practically any figure you wish to represent the annual shortage of engineers, and you can find some authority to confirm your estimate. You may even take a *negative* figure and quote in support of it an article in *Life* magazine last year stating that "technicians are two bits a dozen in America." As I shall suggest later, thoughtless comments of this sort—often taken seriously by high-school students and their teachers—may be one of the causes of our present difficulty.

If we consult more authoritative sources, what do we find? Even here you can take your choice. For there is really no accurate way of adding up the present shortage and still less of projecting it into the future.

But if some rather conservative estimates are taken from such authorities as K. T. Compton, S. C. Hollister, and the Engineering Manpower Commission of the Engineers Joint Council, the following picture can be put together:

1. The present engineering population in this country is about 400,000, of which 300,000 are in industry, 90,000 in government agencies, and 10,000 in education.
2. The present *shortage* is about 95,000; i.e., there are 95,000 military and civilian jobs now vacant.
3. Between now and 1955 the country will need about 33,000 new engineers each year. Hence the accumulated need by 1955 will be for an engineering population of nearly 630,000.
4. The numbers of engineers we may actually have in 1955 can be more accurately predicted. It is the number we now have (400,000) plus the number now in engineering schools who will graduate by 1955. Making no allowance for losses in the meantime, this adds up to 474,000 against the predicted need of 630,000—156,000 short! A shortage increasing at the rate of some 16,000 per year.

These are the most generally accepted figures and are admittedly conservative.

The point I wish to make is this. The above figures of an annual shortage of 16,000 and an accumulated shortage by 1955 of 156,000 may be so conservative they distort the actual situation we face.

Taking a slightly less conservative view, one may arrive at the following picture:

1. If we allow for death, retirement, losses to nontechnical military service, and calling up of reserves and other diversions to nontechnical work, the present rate of supply of new engineers is actually 5,000 *less* than the expected annual losses.
2. The anticipated needs may have also been grossly underestimated. The technical requirements of the new 1.5 billion dollar a year program of military development (three times larger than 1950) have only begun to be felt. The military production program is rapidly climbing. The Atomic Energy Commission has been instructed to initiate a vast 5 billion dollar program of expansion. These national security programs alone could easily demand 30,000 more engineers a year for the next four years. Thus it could easily be true that by 1955 the number of engineers actually needed will be nearly 700,000. And we will actually have less than 400,000.

I do not claim, of course, that these figures are any more accurate than the previous ones. But we should not be blind to the possibility of a potential shortage of 300,000 or to the fact that we may actually be losing rather than gaining ground each year; otherwise, we may fail to understand the true dimensions of our problem. When we face a situation in which there are needs for nearly twice as many engineers (and I might add scientists too) as are available, we are meeting not merely a grave problem but something which more nearly approaches a national catastrophe. For here we are, as a nation, spending 50 billion dollars or more a year to maintain world leadership in military, industrial, and other technology, yet we just do not have the basic wherewithal in trained manpower to do the job we are setting out to do. For the next four years there is practically nothing we can do about it. Furthermore, the causes for the situation lie so deep in American thought and practice that to do anything about it at all presents the gravest difficulties.

As to the first point—that there is nothing we can do about it—the reasons are fairly obvious. It takes four years to train an engineer. Even if the freshman classes next fall in all our engineering colleges were suddenly choked to overflowing, this would not make a dent on the situation until 1956.

There are, of course, a few things we might do to help. We could stop drafting engineers and engineering students. But the difficulties in national policy along that line are only too obvious. (The Armed Forces could, however, stop assigning engineers in uniform to nontechnical jobs.) We can recall to engineering work many fine engineers who have gone into executive, sales, or other nonengineering work. We could hurriedly give subprofessional training to a host of untrained youngsters to relieve the trained engineers of some of the drudgery of drafting and computation. We ought to pay really top-grade engineers much higher salaries than they now receive. We ought to do all these things, and we no doubt will do some of them to a certain extent. But all together they will hardly make up a fifth of the projected shortage of 300,000.

So for the next four years we can adopt only certain palliative measures. And the results will be high wages offered to second-grade men and—worst of all—second-rate engineering jobs done on essential national products in places where only first-rate engineering should be accepted. We shall thereby be purchasing a colossal quantity of second-grade product at a high cost in maintenance and obsolescence—and at an incalculable cost to national security.

What about the long-term future?

This is a field in which one may speculate without restraint. There are those who say we should not worry. They say that high salaries will attract more men into engineering in the long run and things will be automatically adjusted. We can agree that higher salaries are desirable and will help. Also it may be that our high level of national expenditure will be cut back, business conditions may decline, and a reduced demand for engineers will match the then increasing supply. However, I hold a different view.

I believe that—except for occasional recessions—the need and the demand for scientists and engineers is going to continue to rise at an increasing rate for the indefinite future. I see no early easing of world tension; I see no decline in the opportunity for America to continue its world leadership in technology; I see *rising* and not falling opportunities for technological advance all over the world. The age of science and technology has only just begun. And while I am the last one to insist that all the world's problems can be solved by technology alone, I also believe technology can be an important weapon

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in advancing human welfare, i.e., in enabling human beings through social, economic, political and psychological advances to achieve the moral goals of human liberty, decency, and dignity to which all men aspire.

But I see serious obstacles in achieving the scientific and technological advances which are so essential to the progress of human welfare. The major obstacle is right here in this country where the intellectual atmosphere is such as to discourage rather than encourage men and women in entering the field.

This may sound like an extreme statement, but there are many facts to support it. Notice, for example, that in spite of increased population and in spite of increased demand we only had 3 per cent more freshman engineers enrolled in the nation's engineering colleges in the fall of 1951 than in 1940. It is true there was a big bulge in 1946–1949, but this hardly made up for the enormous war-time decrease.

Why are engineering enrollments decreasing?

Obviously, the number of college freshman engineers enrolled depends greatly on what is happening in the high schools. And what has been happening there in the past 50 years is not encouraging. In 1900 about 19 per cent of the nation's high-school students took a course in physics. Today only 5.5 per cent do. Many engineering schools very properly require high-school physics for entrance. Thus the number of available applicants is showing a relative decline. The situation is no better in mathematics, especially in advanced courses. Evidently high-school students, apparently encouraged by teachers, administrators, and counselors, now regard such courses as too tough or too "technical." Counselors advise students to take a "broad" course. This sounds fine. But what it usually means is taking literature or history or politics or "science survey" instead of mathematics and physics and chemistry. Just how poetry is more "broadening" than Newton's laws of motion however somehow escapes me.

High schools are not wholly to blame. There has been for many years a growing feeling among all Americans that the world has too much science and technology already. What we need, they say, is not better engineers but better citizens. Of course we need more and better citizens. But I deny the implication that a bank clerk or lingerie salesman or even a social psychologist is necessarily a better citizen than a scientist or engineer.

What after all is the prime prerequisite of a good citzen?

The first duty of a citizen is to perform a useful function for society. No matter how glibly a man is able to recite in proper order the names of all the presidents of the United States, if that man is not using his talents to the fullest possible extent in a constructive occupation I claim he is *not* being a good citizen. Whether his talents are for designing airplanes or writing good poetry, I don't much care, as long as those talents are being developed and being constructively used. I am not informed as to how many courses in history or political science or social problems were taken by Alexander Graham Bell, the Wright Brothers, or Lee De Forest. Whether they took any or not, they were great citizens because they made useful contributions to society. And when we let our promising high-school students believe you can't be both good engineer and good citizen, we are doing our nation and the world a disservice.

Now, I don't want to be misunderstood. I also believe that the engineer or scientist who does not take an interest in the welfare of his community or his country is failing to fulfill his full obligations as a citizen. And I believe that somewhere in his schooling this point ought to be made clear to him. Furthermore, I believe that an engineer is more likely to be a more useful citizen—and also a more useful engineer—if he devotes an appreciable part of his efforts in high school and college to the study of subjects outside of his specialty and also to constructive activities outside the classroom. But this is not the same as saying he should do these things to the exclusion of accomplishing his primary task—as a citizen and as a man—of developing his primary talents.

One of the reasons for this recent drift away from science and technology is exemplified by the following quotation from a prominent scholar whose name I will not mention: " . . . the root cause of our current world crisis stems from the fact that our technical scientists in their perfection of the techniques of destruction are so far ahead of our social scientists whose principal job it is to teach men how to live together peaceably and constructively."

I can think of only one respectable word to describe such a statement—"eyewash." Because scientists helped prevent the world from being conquered by two groups of power-mad dictators in Berlin and in Tokyo, *therefore* they must be responsible for the current world crisis! Because they helped crush two dictators, it is *their* fault that a third one has appeared! And who says that it is only the social scientist whose aim it is to teach men to live together peaceably and constructively? That is a job for all of us. The ills of the world are not caused by the intelligence of the scientists but by general human cussedness. Not even social scientists are going to find a quick cure for *that*.

I won't bore you with further expostulations about such nonsensical statements—for you can expose them as nonsense as well as I. My point is that more and more people are believing that because science and technology is not *everything*, therefore it is *nothing;* that the way to advance social progress is to *stop* scientific progress; that because man can not live by bread alone, therefore bread is unnecessary and undesirable. When more and more people try to represent scientists and engineers as the villains of the world drama, it is not hard to understand why fewer and fewer youngsters are attracted into these fields.

I think then that you can see why I regard the present manpower situation in science and engineering as something more than a troublesome but unimportant phenomenon—why indeed I assert that it represents something more nearly in the nature of a national crisis.

The numerical shortage itself is serious enough. Everyone would recognize the absurdity of placing orders for 20,000 airplanes to be delivered this year if the proved total supply of aluminum was only enough to build 10,000. But we apparently think nothing of embarking on a program which would require 700,000 engineers when only 400,000 are in sight. The result is plain. We are going to fall flat on our faces. We simply can't deliver what we have ordered.

But the numerical shortage is only a symptom of a deeper ailment. We as a nation have grown dependent on scientists and engineers, and we don't know it and refuse to admit it. And so with one hand we appropriate billions of dollars for work that only scientists and engineers can do—and with the other hand we slap them in the face and accuse them of causing all the world's ills which we then call on them to help cure. As a symptom of all this, the House of Representatives has slashed the budget of National Science Foundation by 77 per cent, one agency of government set up to produce more scientists and engineers and to produce rather than consume basic knowledge.

Are we then wholly helpless to do anything about this crisis? I have already said that there is very little we can do for the short term. But for the long term we can do something. I suggest three things:

1. We can expose this nonsense about technology being the cause of the world's ills, about scientists being unconcerned about human welfare. We can let it be known that human welfare is the major goal for all of us and that we as scientists and engineers stand ready to join hands with all men of good will everywhere to advance that goal. And we have been *doing* it!
2. We can carry this same message to high-school students. You—the members of IRE—could initiate a high-school information campaign to tell high-school students and teachers that engineers are not villains; that the field of science and engineering offers great and exciting challenges for the future; that scientists and engineers can be—and for the most part *are*—good citizens, too. You can tell them that the best citizen is the useful citizen—the one who is using his talents to their fullest. You can invite students to visit your plants, factories, and laboratories and show them how exciting science and technology can be.
3. Finally, I would like to suggest something very definite which you—the members of IRE—can do right here in Southern California. Let us say that Southern California industry is going to need 100 engineers more each year than are now in sight. (I'll choose a modest number to avoid scaring you!) Why shouldn't IRE and the other engineering societies get together and raise, by industrial contributions, a scholarship fund so that each year 100 boys who need financial incentive could be sent to engineering school. For $200,000 a year you could offer 100 four-year scholarships, averaging $2,000 each—$500 a year—to the 100 most promising applicants. And my guess is that for each winner about 3 to 5 others would have their interest sufficiently aroused by the contest so that they would find other sources of funds and go to college anyway. If we in Southern California started such an enterprise, it might be copied in other areas. Properly promoted, such scholarship funds might help reverse the tide of declining interest in science and engineering, would make the voice of scientist and engineer heard again, and eventually help avert a real national calamity.